US009325068B2

(12) **United States Patent**
**Chang**

(10) **Patent No.: US 9,325,068 B2**
(45) **Date of Patent: Apr. 26, 2016**

(54) **BROADBAND ANTENNA DEVICE**


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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 339 days.

(21) Appl. No.: **13/948,623**

(22) Filed: **Jul. 23, 2013**

(65) **Prior Publication Data**

US 2014/0292607 A1 Oct. 2, 2014

(30) **Foreign Application Priority Data**

Mar. 28, 2013 (TW) ............................ 102111267 A

(51) **Int. Cl.**
***H01Q 11/00*** (2006.01)
***H01Q 5/371*** (2015.01)

(52) **U.S. Cl.**
CPC .................................... ***H01Q 5/371*** (2015.01)

(58) **Field of Classification Search**
CPC ............ H01Q 11/00; H01Q 1/24; H01Q 1/38
USPC .......................... 343/843, 702, 700 MS, 846
See application file for complete search history.



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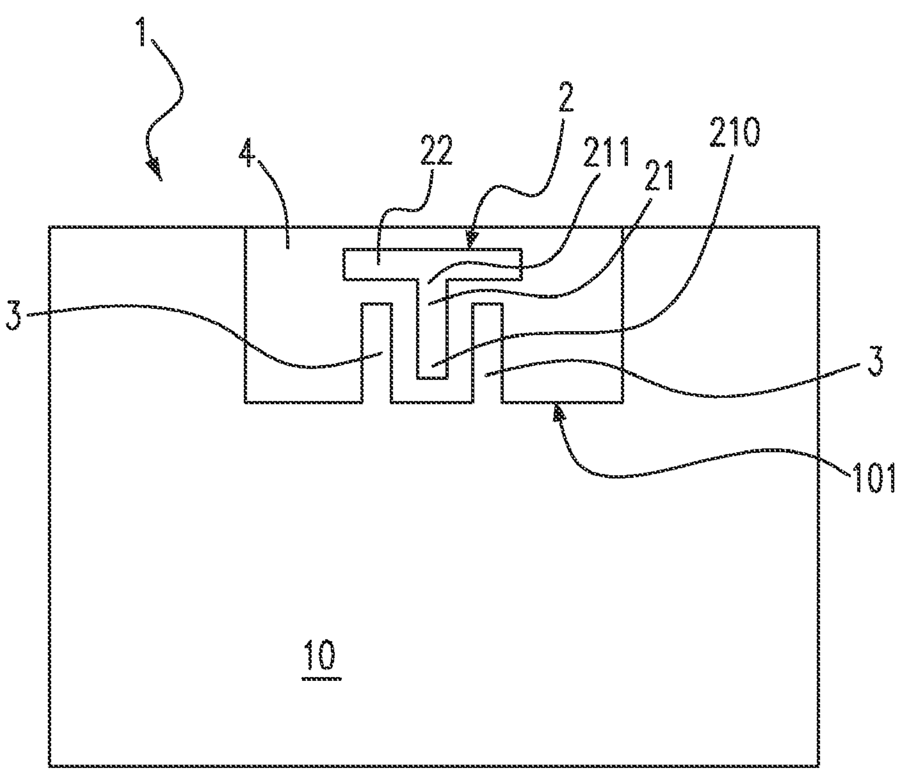
(57) **ABSTRACT**


An antenna device is provided. The antenna device comprises a first radiation portion and a second radiation portion. The first radiation portion includes a first end and a second end. The second radiation portion is connected to the first end at a connecting part and includes a first arm and a second arm. The first arm and the second arm have different lengths and extend from the connecting part.


**17 Claims, 4 Drawing Sheets**



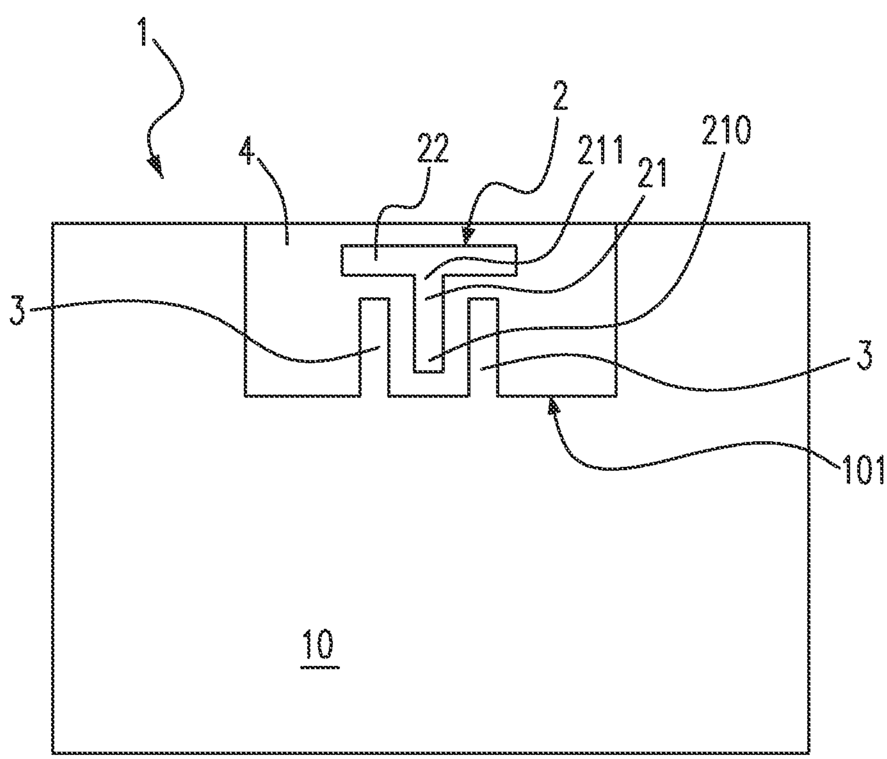



Fig. 1

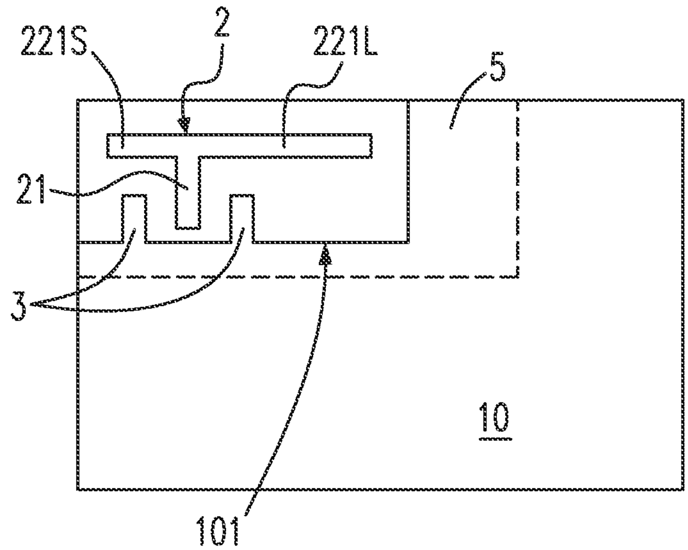



Fig. 2

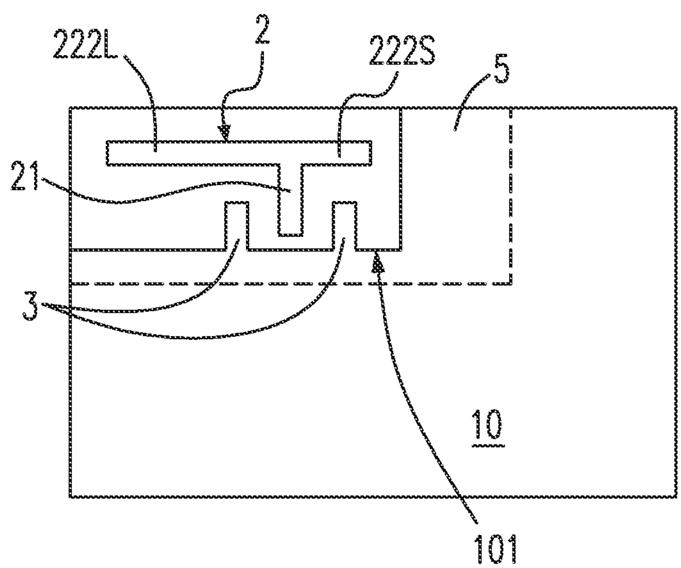



Fig. 3

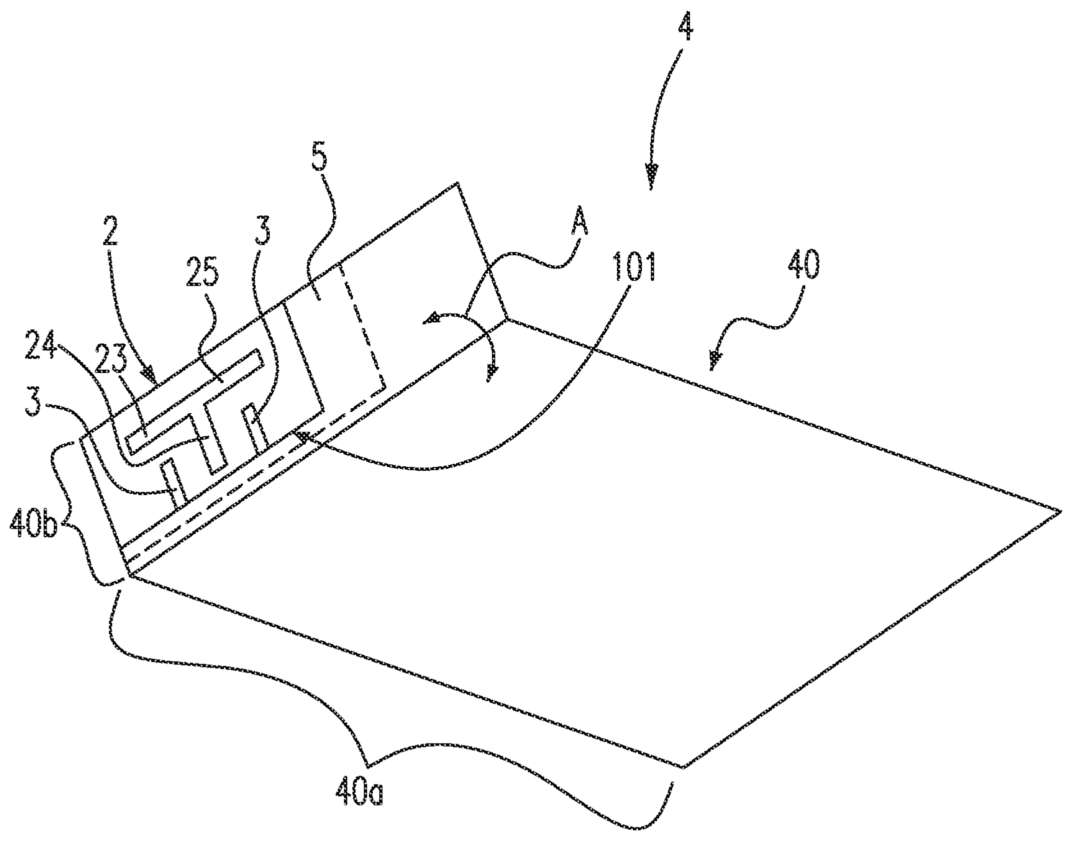



Fig. 4

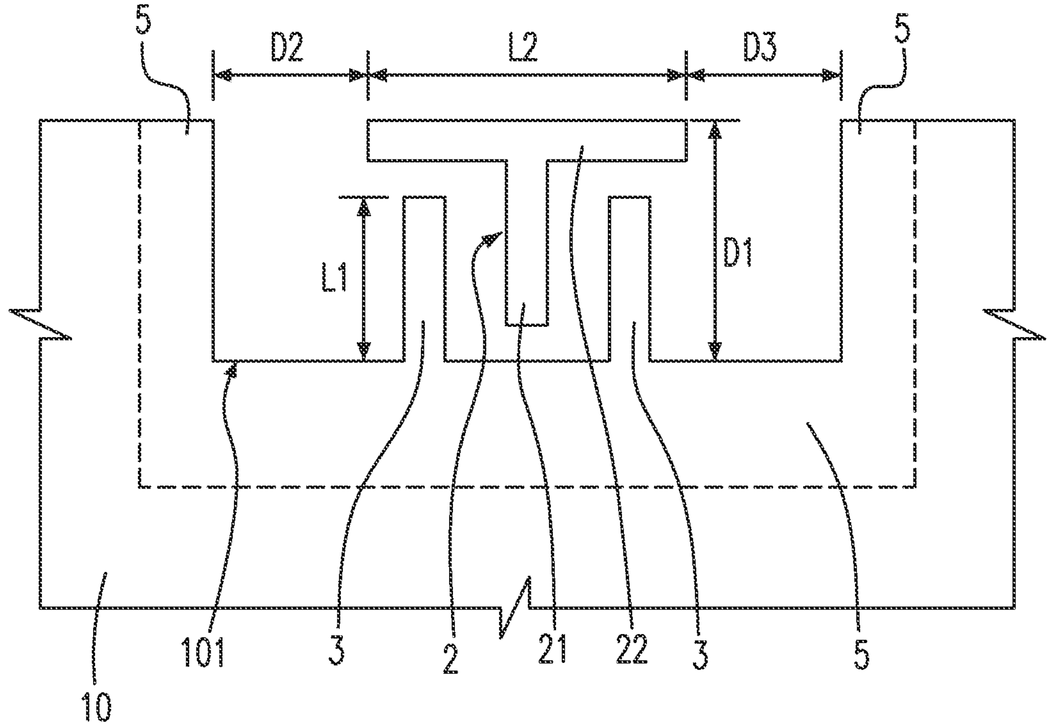



Fig. 5

# BROADBAND ANTENNA DEVICE

The present invention claims the benefits of priority from the Taiwanese Patent Application No. 102111267, filed on Mar. 28, 2013, the contents of the specification of which are hereby incorporated herein by reference

## FIELD OF THE INVENTION

The present application relates to an antenna, particularly to a miniature wideband antenna.

## BACKGROUND OF THE INVENTION

Whip antennas are the most common type of monopole antennas. The whip antennas consist of a single straight flexible wire or rod that usually protrudes from electronic devices such as mobile devices, routers and modems. In contrast to the whip antennas that protrude from the electronic devices, built-in antennas that are installed within electronic devices for proper operation offer a high degree of freedom of design. Not only because of this, but also from the standpoint of reinforcing shock resistance, reduction of manufacturing costs, etc., the requirement for complete built-in antennas for electronic devices, particularly mobile devices, is always growing.

The relative direction of a mobile device with its access point (base station) is determined not only by the orientation of the mobile device but also the location thereof. A challenge to the use of complete built-in antennas in mobile devices is that a mobile device can change its orientation through mobility and rotation. An antenna which is miniaturized and can only provide adequate gain for a limited range of orientations cannot meet the requirements for the mobile device, especially when it is moved or rotated.

In addition, for home wireless routers or modems, even if the whip antennas configured thereon have adjustable angles, the wireless signals transmitted from the wireless routers or modems will be affected by the place where the wireless router or modem is located. That is, metal objects, walls, floors and so on will interfere with the router's wireless signals, and the closer the router is to these obstructions, the more severe the interference is, and the weaker signal strength will be.

To overcome the mentioned problems, novel antenna devices are provided in the present disclosure after a lot of research, analysis and experiments by the inventors.

## SUMMARY OF THE INVENTION

One of the purposes of the present invention is to downsize an antenna by the design of the meandering shape of an antenna without decreasing the radiation efficiency and narrowing the bandwidth thereof. Specifically, this purpose can be achieved by using two radiators electrically connected to each other and extending in different directions.

In accordance with one aspect of the present disclosure, an antenna device is described. The antenna device comprises a first radiation portion and a second radiation portion. The first radiation portion includes a first end and a second end. The second radiation portion is connected to the first end at a connecting part and includes a first arm and a second arm. The first arm and the second arm have different lengths and extend from the connecting part.

In accordance with another aspect of the present disclosure, an antenna device is described. The antenna device comprises an antenna area including at least one impedance



matching structure and a ground area directly connected to the antenna area via the at least one impedance matching structure.

In accordance with a further aspect of the present disclosure, an antenna device is described. The antenna device comprises a first radiation portion, a second radiation portion and an impedance matching structure. The first radiation portion includes a first end and a second end. The second radiation portion is connected to the first end at a connecting junction. The second end includes a feeding point and the impedance matching structure is configured nearby the feeding point.

The above objectives and advantages of the present disclosure will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed descriptions and accompanying drawings, in which:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram showing an antenna device according to a first embodiment of the present invention;

FIG. **2** is a diagram showing an antenna device according to a second embodiment of the present invention;

FIG. **3** is a diagram showing an antenna device according to a third embodiment of the present invention;

FIG. **4** is a diagram showing an antenna device according to a fourth embodiment of the present invention; and

FIG. **5** is a diagram showing the dimension of an antenna device according to a fifth embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A detailed description of embodiments of the present invention is provided with reference to the FIGS. **1**-**11**.

The present disclosure will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this disclosure are presented herein for the purposes of illustration and description only; it is not intended to be exhaustive or to be limited to the precise form disclosed.

Please refer to FIG. **1**, which shows an antenna device according to a first embodiment of the present invention. The antenna device **1**, which is preferably a broadband antenna device, comprises a substrate **10**. On the substrate **10**, there is an antenna area **101** in which an antenna **2** is configured. The antenna **2** includes a first radiator **21** and a second radiator **22**. The first radiator **21** includes a feeding end **210**, which may be a feeding point, and a connecting end **211**. The first radiator **21** of the antenna **2** of the present application is directly connected to the second radiator **22** via the connecting end **211**. The connecting part between the first radiator **21** and the second radiator **22** forms a three-way junction, which is preferably a T-junction. The first and the second radiators **21**, **22** have a bar shape and preferably a uniform width. The first and the second radiators **21**, **22** on the substance **10** are rectangular-shaped radiators which extend in different directions, which are preferably opposite directions. Preferably, the extending direction of the first radiator **21** is perpendicular to that of the second radiator **22**. Further, the long side of the second radiator **22** is connected to the connecting end **211** of the first radiator **21**. That is, the short side of the first radiator **21** is connected to the long side of the second radiator **22**. Based on the connecting end **211** of the first radiator **21**, the second radiator **22** has a left arm and a right arm preferably with the same width. The left arm and the right arm extend from the three-way junction. The left arm may have a length the same as or different from that of the right arm. The feeding end **210** may route the RF signals via a coaxial cable, a microstrip line or coplanar waveguide (CPW) (not shown). The radiators in accordance with the present disclosure which extend in two different directions cause two different emission flats, and thus cover almost all emission directions.

In addition, a ground area (not shown) may be configured adjacent to the antenna area **101**, and an impedance matching structure **3** may be configured between the second radiator **22** and the first radiator **21**. The impedance matching structure **3** with an extending direction substantially the same as that of the first radiator **21** may be configured on either side or both sides of the first radiator **21**. Further, in the antenna area **101**, the space excluding the first radiator **21**, the second radiator **22**, and the impedance matching structure **3** may be filled with a dielectric substance to insulate the first and second radiators **21**, **22** from the ground area (not shown). The portion excluding the antenna area **101** and the ground area on the substrate **10** may be provided with other electronic elements (not shown). In such conditions, a metal layer such as copper foil for the printed circuit board could be configured on said portion of the substrate **10** to electrically connect to other electronic elements. Said metal layer or the like and other electronic elements cannot be configured in the antenna area **101** either on the side where the antenna **2** lies or the side opposite thereto, i.e. the back of the substrate **10**.

Please refer to FIG. **2**, which shows an antenna device according to a second embodiment of the present invention. In this embodiment, the antenna area **101** is located at one of four corners of the substrate **10**. In the antenna area **101**, there is configured an antenna **2**. The antenna **2** comprises a bar-shaped first radiator **21** with two ends. A first short arm **221**S and a first long arm **221**L are extended transversely from one end of the first radiator **21** in opposite directions. That is, the second embodiment shows a modification in the lengths of the left arm and the right arm of the second radiator **22** of the first embodiment in FIG. **1**. Further, in the second embodiment, the impedance matching structures **3** are configured on both sides of the first radiator **21**. It can be appreciated that the impedance matching structure **3** can be configured on either side or both sides of the first radiator **21**.

Please refer to FIG. **3**, which is a diagram showing an antenna device according to a third embodiment of the present invention. In this embodiment, the antenna area **101** is located at one of four corners of the substrate **10**. In the antenna area **101**, there is configured an antenna **2**. The antenna **2** comprises a bar-shaped first radiator **21** having two ends. A second short arm **222**S and a second long arm **222**L are extended transversely from one end of the first radiator **21** in opposite directions. Further, in the third embodiment, an impedance matching structure **3** is configured on either side of the first radiator **21** and electrically connected to the ground area **5** to reduce noise in the radio transmission and interference with other electronic elements (not shown) on the substrate **10**.

Please continue to refer to FIGS. **2** and **3**. Because one purpose of the present invention is to reduce the overall size of the antenna device, it is preferred that the antenna area **101** where the antenna **2** is located is designed inside the substrate **10**, e.g. at four corners or near four sides thereof. Since the remaining portions on the substrate **10** may be used to set some electronic elements (not shown) to fully utilize the space in the antenna device such as a home wireless router or modem, a ground area **5** is configured around the antenna area **101** on the substrate **10** to avoid interference with said electronic elements on the remaining portions of the substrate **10**. That is to say, the antenna area **101** is directly connected to the ground area **5** via the impedance matching structure **3**. However, the ground area **5** may cause limitations in the voltage standing-wave ratio (VSWR), which is also referred to as standing-wave ratio (SWR). The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0, and in this case, no power is reflected from the antenna, which is ideal. Generally, to satisfy a bandwidth requirement without damaging the electronic elements, it is preferred to have a VSWR less than 3. On the premise that the VSWR is less than 3, the second embodiment with the first long arm **221**L pointing to the ground area **5** is better than the third embodiment. That is to say, when the second and the third embodiments have the same bandwidth, the VSWR of the second embodiment in FIG. **2** is smaller than that of the third embodiment in FIG. **3**. In other words, if the second and the third embodiments have the same VSWR, the second embodiment will have a bandwidth wider than that of the third embodiment. However, in the actual application, the concrete demand is the major consideration. Both the second and third embodiments can achieve the purpose of size reduction of the antenna devices according to the present application and providing vast coverage range for the electromagnetic waves.

Please refer to FIG. **4**, which is a diagram showing a broadband antenna device **4** according to a fourth embodiment of the present invention. The broadband antenna device **4** includes a flexible circuit board **40**. The circuit board **40** has a first portion **40***a* and a second portion **40***b*, and the angle therebetween is denoted by the letter "A". An antenna area **101** where an antenna **2** is configured is disposed in the second portion **40***b* of the circuit board **40**. The antenna **2** in this embodiment is a three-way intersectional antenna including a first arm **23**, a second arm **24** and a third arm **25**. The second arm **24** of the antenna **2** includes a feeding point. The antenna area **101** can be configured at the corner of the second portion **40***b*, so that tire remaining space on the second portion **40***b* can be used to place other electronic elements (not shown). In this case, because of the presence of other electronic elements, it is better to configure a ground area **5** around the antenna **2** on the second portion **40***b* to receive partial electromagnetic waves. One or more impedance matching structures **3** may be configured in the antenna area **101** in a manner similar to that described for the first embodiment. When the impedance matching structure **3** is a solo one, the solo impedance matching structure **3** is configured at a position being one of between the first and the second arms and between the second and the third arms, and when the impedance matching structure **3** has plural ones, the plural impedance matching structures **3** are separately configured between the first and the second arms and between the second and the third arms.

Please refer to FIG. **5**, which is a diagram showing the dimension of an antenna device according to a fifth embodiment of the present invention. The dimension is presented by $\lambda g$, wherein 1 $\lambda g$ denotes one-guide wavelength of the center operating frequency of the operating frequency band in the medium on the condition that the VSWR is less than 3.0. In the fifth embodiment, the layout in the antenna area **101** including the antenna **2** and the impedance matching structures **3** is similar to that in the antenna area **101** of the first embodiment, and thus the descriptions therefor are omitted. The first radiator **21** and the second radiator **22** in the fifth embodiment form a T-shaped antenna **2** in the antenna area **101**. The impedance matching structures **3** have an extending direction substantially the same as that of the first radiator **21** and a length L1 in its extending direction. The length L1 is in a range of 0-0.25 λg. The second radiator **22** has a length L2 in its extending direction as shown in FIG. **5**. The length L2 is chosen such that 0.13 λg<L2<0.375 λg.

Since the antenna area **101** shares one side with the substrate **10**, a ground area **5** is configured to surround the circumference excluding the shared side of the antenna area **101**. That is, the antenna area **101** and the remaining portions on the substrate **10** are separated by the ground area **5**. As shown in FIG. **5**, the distance from the upper rim of the second radiator **22** to the ground area **5** is defined as a first distance D1. The first distance D1 is chosen such that 0.166 λg<D1<0.375 λg.

In FIG. **5**, the second radiator **22** has a left end and a right end. The distance from the left end of the second radiator **22** to the ground area **5** is defined as a second distance D2, which is greater than 0.01756 λg. If possible, preferably the second distance D2 is greater than 0.166 λg. The distance from the right end of the second radiator **22** to the ground area **5** is defined as a third distance D3, which is greater than 0.166 λg. The maximums of the second distance D2 and the third distance D3 are not limited but depend on the dimension of the substrate.

The broadband antenna devices according to various embodiments in the present application have reduced dimensions and provide a much larger range of orientations due to the different orientations of the first and the second radiators. Since the two radiators are connected to each other at a particular angle, the radiation directions thereof intersect at that particular angle as well. The particular angle may be 90° or other appropriate angles. In each embodiment of the present disclosure, the radiating directions of the electromagnetic waves will be perpendicular to the long sides of the bar-shaped radiators, and thus the second radiator **22** in the T-shaped antenna would have a vertical radiating direction and the first radiator **21** in the T-shaped antenna would have a horizontal radiating direction. The reception or transmission of the electromagnetic waves in all directions can be achieved by using the antenna device based on the present disclosure. For a mobile communication device where the antenna device is configured, even if the mobile communication device is moved or rotated and thus the orientation of the antenna toward the base station changes, the antenna in the antenna device according to the present disclosure can effectively receive and transmit signals. For home wireless routers or wireless access points (AP), even if the router or AP is positioned near obstructions such as a wall, the emission of the electromagnetic waves from the antenna of the antenna device according to the present disclosure would not be obstructed. Based on the above, the layout of the antenna device according to the present disclosure can realize the downsizing of the overall antenna device and the increased directivity without decreasing the radiation efficiency or narrowing the bandwidth.

While the disclosure has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the disclosure needs not be limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

What is claimed is:

**1**. An antenna device, comprising:
- a first radiation portion including a first end and a second end;
- a second radiation portion connected to the first end at a connecting part and including a first arm and a second arm, wherein the first arm and the second arm have different lengths, extend from the connecting part and are a left arm and a right arm respectively;
- a first impedance matching structure formed between the left arm and the first radiation portion; and
- a second impedance matching structure formed between the right arm and the first radiation portion.

**2**. An antenna device of claim **1**, wherein the connecting part is a three-way junction, the left arm and the right arm are directly connected to and extend from the three-way junction and have a first and a second extension directions extending from the three-way junction, the first and the second extension directions are opposite to each other, and the first radiation portion and the second radiation portion are configured in an antenna area.

**3**. An antenna device of claim **2**, further comprising a ground region adjacent to the antenna area.

**4**. An antenna device of claim **3**, further comprising a dielectric substance configured in the antenna area and insulating the first and second radiation portions from the ground region.

**5**. An antenna device of claim **3**, wherein the antenna area is surrounded by the ground region.

**6**. An antenna device of claim **1**, wherein the first and the second impedance matching structures are electrically connected to the ground region.

**7**. An antenna device of claim **1**, wherein the connecting part is a T-shaped junction.

**8**. An antenna device of claim **1**, wherein the second end includes a feeding point.

**9**. An antenna device, comprising:
- an antenna area including a plurality of impedance matching structures;
- a ground area directly connected to the antenna area via the plurality of impedance matching structures; and
- a three-way intersectional antenna configured in the antenna area,
- wherein the three-way intersectional antenna includes a first arm, a second arm and a third arm, and the plural impedance matching structures are separately configured between the first and the second arms and between the second and the third arms.

**10**. An antenna device of claim **9**, wherein the second arm includes a feeding point.

**11**. An antenna device of claim **10**, wherein the first arm and the ground area have a nearest distance therebetween being greater than 0.166 kg.

**12**. An antenna device of claim **10**, wherein the first arm has a first length and the third arm has a second length, and the second length is longer than the first length.

**13**. An antenna device of claim **12**, wherein the third arm and the ground area have a nearest distance therebetween being greater than 0.166 kg.

**14**. An antenna device, comprising:
- a first radiation portion including a first end and a second end, wherein the second end includes a feeding point;
- a second radiation portion connected to the first end at a connecting junction and including a left arm and a right arm;
- a first impedance matching structure configured near the feeding point and between the left arm and the first radiation portion; and
- a second impedance matching structure configured between the right arm and the first radiation portion.

**15**. An antenna device of claim **14**, wherein the connecting junction is a three-way junction, and the left arm and the right arm have an identical width and extend from the three-way junction in two opposite directions.

**16**. An antenna device of claim **14**, wherein the second radiation portion has a length ranging between 0.13-0.375 $\lambda g$.

**17**. An antenna device of claim **14**, wherein the impedance matching structure has a length greater than 0 $\lambda g$ and less than 0.25 $\lambda g$.

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